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Self Control in Society, Mind, and Brain
Ran Hassin (ed.) et al.
https://doi.org/10.1093/acprof:oso/9780195391381.001.0001
Published: 2010 Online ISBN: 9780199776894 Print ISBN: 9780195391381

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CHAPTER

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# CHAPTER 5 Integrating Research on Self-Control across Multiple Levels of Analysis: Insights from Social Cognitive and Affective Neuroscience

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https://doi.org/10.1093/acprof:oso/9780195391381.003.0005 Pages 76–92
Published: March 2010

## Abstract

Advances in neuroimaging methods and techniques and interest in understanding the neural bases of psychological phenomena are rapidly changing how the capacity for self-control is being addressed. An approach dubbed Social Cognitive and Affective Neuroscience (SCAN) integrates research across multiple levels of analysis, leading to important findings that link the basic social, cognitive, and affective processes underlying self-control to their neural substrates. This chapter illustrates how a SCAN approach can be useful for addressing questions including the problem of how to enable researchers from different areas with different types of expertise and interests in self-control to communicate with one another and most effectively use each other’s (sometimes highly technical) theories and methods. Towards this end, we begin by describing the basic goals of SCAN and some of the key challenges facing researchers who adopt this approach. We then describe how this approach is currently being used to build an integrative understanding of the processes underlying a particular type of self-control process that involves actively reinterpreting the meaning of an emotionally evocative stimulus to meet and/or modulate ones’ feelings. We conclude by discussing important future research directions in this area.

**Keywords:** Social cognitive and affective neuroscience, emotion, emotion regulation, fMRI, cognition-emotion interactions

**Subject:** Neuropsychology, Social Psychology

**Collection:** Oxford Scholarship Online

The famous American novelist Jack Kerouac once wrote, “My fault, my failure, is not in the passions I have, but in my lack of control of them.” This quote poignantly illustrates a basic fact about human experience. Namely, that although people often cannot prevent themselves from experiencing certain “passions,” they possess remarkable abilities to control them once they are aroused. This capacity for *self-control*–the ability to volitionally influence the content of one’s thoughts, the nature of one’s feelings, and expression of one’s actions to align them with ↳ one’s long-term goals and standards–is fundamental to human survival and success in the modern world. Consequently, a critical challenge is to understand the processes that underlie it*.

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Although this basic issue has been the focus of psychological and philosophical inquiry for centuries, recent advances in neuroimaging methods and techniques, coupled with a surge of interest in understanding the neural bases of psychological phenomena, are rapidly changing how it is being addressed. Historical boundaries between different areas of psychology are rapidly being broken, and collaborative endeavors are being forged as part of new interdisciplinary Social Cognitive and Affective Neuroscience (SCAN) approaches that aim to integrate research across multiple levels of analysis (e.g., Blakemore & Frith, 2004; Blakemore, Winston & Frith, 2004; Cacioppo, 1994, 2002; Davidson, Jackson, & Kalin, 2000; Insel & Fernald, 2004; Lieberman, 2000, 2007; Ochsner, 2007; Ochsner & Lieberman, 2001; Ochsner & Schacter, 2000; Panksepp, 1998).

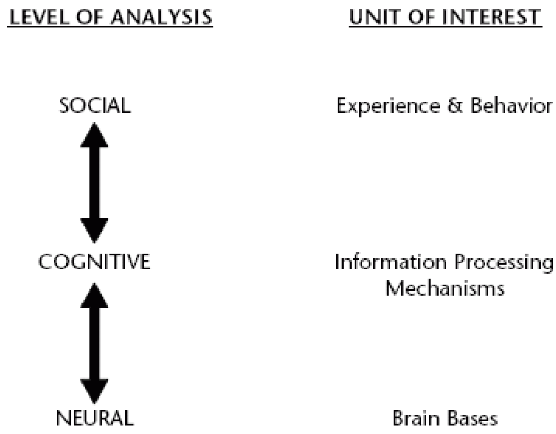
This movement towards integration has already led to a number of important findings that link the basic social, cognitive, and affective processes underlying self-control to their neural substrates (for reviews, *see* Cacioppo, 2007; Lieberman, 2007; Ochsner, 2007). However, it has also met a number of formidable challenges, including the problem of how to enable researchers from different areas with different types of expertise and interests in self-control to communicate with one another and most effectively use each other's (sometimes highly technical) theories and methods.

## DEFINING THE SOCIAL COGNITIVE & AFFECTIVE NEUROSCIENCE APPROACH

Although social cognitive and affective neuroscience are often considered to be distinct disciplines (for discussion, *see* Ochsner, 2007), they share the goal of trying to understand human social and emotional behaviors at multiple levels of analysis and rely upon many of the same theories, methods, tools, and techniques for achieving that goal (Olsson & Ochsner, 2008). With this in mind, for present purposes, we explicitly insert the term "affective" into what we've previously described as the "social cognitive neuroscience approach" (e.g., Ochsner, 2007; Ochsner & Lieberman, 2001) to reflect the increasingly blurry lines that separate the sister disciplines of social cognitive and affective neuroscience.

As used here, the "social cognitive and affective neuroscience" approach describes attempts to explain psychological phenomena across three different levels of analysis: the social level of behavior and experience, the cognitive level of mental representations and process, and the neuroscience level of brain systems (*see* Fig. 5–1). The basic idea is that information from each of these levels of analysis is needed to build integrative models of the mechanisms underlying complex psychological phenomena, in part because models are more powerful when they can explain data across multiple levels of analysis, and in part because data from any one level can constrain inferences about variables cached at any other level of analysis. Thus, whereas work at the social level uses paradigms that simulate self-control dilemmas that people are likely to encounter in everyday life to reveal how different types of personal- or situation-level variables (e.g., situational forces, personality dispositions) impact self-control, work at the cognitive level uses more circumscribed tasks to shed light on the specific information processing mechanisms (i.e., psychological processes, such as attention, memory, language, emotion, attitudes) that underlie these social level processes, and findings at the neuroscience level use neuroimaging and other biological measures to indicate how these processes are instantiated in the brain. By putting these different levels of analysis together, an integrative understanding of the processes underlying self-control emerges.

**Figure 5–1.**




**Units of Interest at the Social, Cognitive, and Neural Levels of Analysis.**

It is important to recognize that SCAN's focus on integration, although novel in its current instantiation, is not new. Historically, two of the three levels of analysis described in Figure 5–1 have been linked. Specifically, beginning in the 1970s, social psychologists
p. 78 began to use the information processing concepts of cognitive psychology to describe the mechanisms ↳ underlying social phenomena (e.g., Higgins, Rholes, & Jones, 1977; Taylor, 1976). Adopting this information-processing framework provided social psychologists with a common language to compare and contrast different phenomena. Thus, rather than having to invent new terms to explain different effects, basic information-processing concepts (e.g., accessibility, schemas, and attention) began to be used, giving birth to the field of social cognition.

Roughly a decade and a half later, a similar merging took place between cognitive psychology and neuroscience. The impetus for this union was the advent and subsequent proliferation of functional neuroimaging methods such as positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) that allowed researchers to examine how neural activity changed when healthy people engaged in different types of psychological tasks. The goals of this integration were twofold. First, to examine the information processing functions provided by different brain regions. Second, to use neuroscience methods as a tool to draw inferences about psychological processes (Ochsner & Kosslyn, 1999; Posner & DiGirolamo, 2000). To the extent that the brain is the organic material that underlies all information processing, psychologists working in cognitive psychology and neuroscience reasoned that important insights could be gleamed by investigating the patterns of brain activity engaged by different types of tasks (Kosslyn, 1999; Ochsner & Lieberman, 2001). Thus "cognitive neuroscience" was born as an approach that used a variety of neuroscience methods to study the neural bases of information processing.

The main purpose of SCAN is to move one step further along this path towards integration. It aims to use the methods and principles of cognitive neuroscience to shed light on the neural and cognitive underpinnings of social and emotional phenomena. In this vein, SCAN has two specific goals (Ochsner, 2007; Ochsner & Lieberman, 2001; *see also*, Sarter, Berntson, & Cacioppo, 1996). Goal one is to link specific patterns of brain activity to specific types of psychological processes. The focus is thus on drawing *functional inferences* about what different brain structures and systems do. Goal two is to use information about brain function to draw inferences about the psychological processes underlying social phenomena. The emphasis here is thus on drawing *psychological inferences* about the processes underlying a given behavior by using the activation of brain systems as markers for the occurrence of particular kinds of psychological processes. For example, consider the common case in which a researcher predicts that two behaviors are mediated by the same underlying mechanisms. One way to test this prediction is by using neuroimaging data. To the extent that this hypothesis is correct, one might expect to find similar patterns of neural activity underlying both types of behaviors. Alternatively, to the extent one predicts the opposite, that two types of ostensibly similar processes are mediated by different underlying mechanisms, than one would expect to observe the reverse—namely, different patterns of neural activity underlying the two behaviors (e.g., Kosslyn & Ochsner, 1994; Schacter, Alpert, Savage, Rauch, & Albert, 1996). Thus, to the extent that the psychological inferences one draws about psychological process from brain activity are valid, neuroimaging methods provide psychologists with a powerful window into how the mind operates when individuals engage in different kinds of carefully constructed psychological tasks that can be used to constrain psychological theorizing about how different processes interact.



## Essential Challenges Associated With Adopting a SCAN Approach

Integrating across levels of analysis is not without its challenges. As one moves up and down the levels of analysis illustrated in Figure 5–1, different types of constraints appear that limit the inferences researchers can draw from their studies. In this section, we briefly describe what we perceive to be two of the key challenges facing researchers who adopt this approach.

The first challenge concerns a researcher's ability to draw inferences about the psychological processes that different patterns of brain activity reflect. Assuming that an experiment is well-designed so that it targets a particular psychological process, the degree to which a researcher can be confident that the pattern of neural activity observed in response to their task reflects a particular psychological process depends greatly on the reliability with which that particular function can be ascribed to a particular brain system (Ochsner, 2007; Poldrack, 2006). In the case of some psychological processes that have received a great deal of empirical attention at the neuroscience level of analysis, the reliability of the inferences one draws can be fairly strong. For example, a researcher can be reasonably confident that activation of the primary visual cortex (V1) reflects processes involved in early pattern recognition. As one moves up the ladder in Figure 5–1 to the social level of analysis, however, relatively less is known about the neural bases of many emotional and social cognitive processes. Thus, it is difficult for a researcher to draw strong psychological inferences about the processes reflected by brain activity observed in response to the tasks designed to focus on these processes. Consequently, researchers adopting this approach may be left in the precarious position of observing significant patterns of neural activity in their experiments, but not being able to confidently interpret their psychological meaning (for examples, *see* Ochsner, 2007).

A second challenge facing the integration-minded researcher concerns the issue of generalizability—how one can be confident that laboratory findings apply to people's real-world behaviors and experiences. There are multiple constraints associated with using neuroimaging methods, especially fMRI, to examine how brain activity changes in response to specific tasks. For example, individuals must lie motionless in an enclosed, cold, hollow tube for a prolonged period of time. In addition, fMRI studies typically require designs in which participants are repeatedly exposed to the same stimulus to acquire reliable estimations of neural activity (for overview of methods, *see* Wager et al., 2007). Thus, a study examining the neural processes underlying the generation of emotion might involve repeatedly exposing participants to gory pictures tens, if not hundreds, of times. Clearly, this is not the way most individuals typically experience negative affect under normal life circumstances. As such, as researchers design studies with the intent of drawing inferences not just about the social and cognitive level of analyses, but the neural level of analyses as well, the ecological validity of their experiments often declines, and along with it, the confidence with which they can generalize from the results of their experiments to more complicated, real-world situations involving self-control.

We describe these issues here not to discourage people from adopting a SCAN approach or to belittle researchers who actively employ it, but rather to make clear some of the trade-offs associated with it. In the next section, we discuss how a SCAN approach is currently being used to shed light on a particular form of self-control—the cognitive reappraisal of intense negative emotional responses–and how researchers engaged in this work are actively trying to overcome the challenges described above.

## IMPLEMENTING THE SOCIAL COGNITIVE AND AFFECTIVE NEUROSCIENCE APPROACH: A CASE STUDY IN THE COGNITIVE REAPPRAISAL OF NEGATIVE EMOTION

Given the integrative goals of SCAN, the first step involved in adopting this approach involves identifying how the phenomenon one is interested in plays out across each of the three different levels of analysis that one ultimately hopes to integrate. Possessing this p. 80 basic knowledge ↳ serves two vital functions. First, it provides the aspiring SCAN researcher with the raw ingredients needed to develop integrative models of self-control. Second, it gives researchers from different areas of psychology with different backgrounds and types of expertise a common foundation for discussing common interests, constructing experiments, and building collaborations. In this section, we simulate what this first step might look like for an integration-minded researcher with interests in understanding the processes underlying people's ability to exert self-control over their emotional responses by cognitively reinterpreting how they're feeling. In this vein, we begin by summarizing key findings from social cognitive and cognitive neuroscience research—two disciplines that together capture all three of the levels of analysis illustrated in Figure 5–1–that are relevant to understanding the processes underlying this specific type of self-control process.

### Work Bridging the Social and Cognitive Levels of Analysis

Since the dawn of the cognitive revolution over 40 years ago, a major focus of psychological research has been to shed light on how a people's subjective construals of their experiences influence their feelings (Kelly, 1955). Lazarus was one of the first to empirically demonstrate this phenomenon. For example, in a now classic study he instructed participants to imagine that a stress-inducing video clip about penile circumcision depicted a fake event. Compared to participants who considered the event to be real, those adopting the "fake" perspective displayed significantly lower levels of physiological arousal (Lazarus & Alfert, 1964). This study established that simply providing participants with a different way of thinking about an aversive stimulus had dramatic influences on their subsequent emotional responses.

Subsequent work by Mischel and colleagues extended these initial findings by specifying the specific kind of reappraisal processes that facilitate and undermine adaptive self-control (for reviews, *see* Chapter 23; Mischel, Shoda, & Rodriguez, 1989). According to Mischel, whether reappraisal, or reconstrual, as this process is also commonly labeled, helped or hindered the individual trying to regulate their impulses and emotions depended critically on the type of reappraisal operation they engaged in—or in other words, how they mentally represented an affect-eliciting cue. For example, in the classic delay of gratification studies a child is presented with the option of receiving one treat immediately (e.g., a cookie or marshmallow) or two treats if they wait an undisclosed period of time. Critically, cueing a child to mentally represent the desired treat in terms of its concrete, "hot," consummatory features (i.e., think about how it would taste and smell), undermined their delay of gratification ability. In contrast, cueing a child to mentally represent the same stimulus in terms of its abstract, "cool", informative features (i.e., think about its shape and color) enhanced their delay of gratification ability.

The results from these early studies examining the effects of reappraisal on self-control have been extended in a variety of ways by contemporary research (for a review, *see* Gross, 1998). One particularly noteworthy development has been the development of a number of dual process theories of self-control, which provide a framework for conceptualizing how reappraisal processes impact people's ability to regulate their impulses and emotions. Although many dual process theories exist, most agree that two types of information processing systems govern self-control (for several examples of such theories, *see* Chaiken & Trope, 1999; Carver, 2005; Epstein, 1994; Lieberman, 2007; Metcalfe & Mischel, 1999; Strack & Deutsch, 2004). One system is automatic (or "bottom-up"), driven by the perception of perceptual inputs, operates outside of conscious awareness, and is specialized for quickly processing emotional stimuli. The other system is controlled (or "top-down"), requires cognitive resources to operate, and generates deliberate, reflective, and strategic behavior.

According to these models, managing negative emotions via reappraisal involves activating the controlled, deliberate system to modulate emotions generated by the automatic system. To illustrate, consider again the hungry child in the delay of gratification p. 81 task. When presented with ↳ the image of a cookie, the child automatically experiences an impulse to consume the cookie. This impulse can be modulated, however, if the child thinks about the cookie as a dirty brown disc (i.e., a controlled system mediated reappraisal process), rather than a delicious cookie. In this example, a controlled system strategy is being generated to reduce the child's impulse to consume the cookie. It is important to note, however, that not all types of controlled system mediated strategies facilitate impulse and emotion control. People are capable of generating any number of reappraisal strategies via this system, and as Mischel and colleagues demonstrated over thirty years ago, whether reappraisal helps or hinders the individual in their attempts at self-control depends critically on the type of reappraisal process they engage in. Thus, the child in the example above who reappraises the chocolate chip cookie not as a dirty brown disc, but rather as the most delicious looking cookie ever baked, is likely to enhance rather than diminish their impulse to consume the item.

## Work Linking the Cognitive and Neuroscience Levels of Analysis

Findings linking the social and cognitive levels of analysis reviewed above suggest that the effects of cognitive reappraisal on emotion are mediated by two sets of information processing systems, one that is automatic and specialized for generating automatic emotional responses and one that is controlled and capable of modulating automatically triggered emotional impulses. In this section, we describe research on the specific brain systems that may underlie these different information-processing systems.

### Regions involved in generating emotion

One area that has consistently been found to play a role in emotional responding is the amygdala. The amygdalae are almond shaped subcortical structures located along the medial wall of each of the temporal lobes that have been implicated in a number of different types of processes that relate to making affective evaluations. For example, a number of studies indicate that this set of brain structures are critical for fear conditioning in animals (LeDoux, 2000) and humans (Buchel & Dolan, 2000; LaBar et al., 1995), and for consolidating explicit memory for emotionally arousing events (Cahill et al., 1995; Hamann et al., 1999). Although the amygdalae have been most extensively studied in the context of fear, they respond to the arousing properties of additional kinds of emotional stimuli, both positive and negative, as well (Adolphs & Tranel 1999; Hamann et al., 1999; Wager et al., 2008).

Beyond the amygdala, a number of other brain structures play an important role in affective evaluations, and are thus likely to be involved in the process of generating initial emotional responses. The insula, for example, is responsive to physical pain and signals the presence of disgust-related stimuli (Peyron, Laurent, & Garcia-Larrea, 2000). In addition, the orbitofrontal and ventromedial prefrontal cortex are sensitive to the same types of stimuli as the amygdala, but seem to play a special role in placing these associations under the control of situational goals. In most studies this is examined in the context of altering an existing affective association as the value of a stimulus changes over time. For example, orbitofrontal lesions in primates (Dias, Robbins, & Roberts, 1997) and in humans (Fellows & Farah, 2003) impair the ability to alter a stimulus-reinforcer association once it is learned, and single unit recording studies in rats and primates suggest that orbitofrontal cortex neurons change their firing properties to previously rewarded (but now not rewarded) stimuli more rapidly than do amygdala neurons (Rolls et al., 1996; *see also* Wager et al., 2008).

### Regions involved in implementing reappraisal

In the same way that the experience of emotion is not dependent on a single brain region, it is likely that the process of reappraising an emotion to change how one feels should depend on a number of brain regions. In prior research, Ochsner and colleagues (2004) speculated that the ability to reappraise an emotionally evocative stimulus should depend on component processes that enable people

to (a) actively generate ↳ strategies for reframing emotional stimuli and maintaining these strategies in working memory, (b) mediate interference between top-down interpretations of stimuli (e.g., reappraisals) and bottom-up appraisals that may continue to generate affective impulses, and (c) reinterpret the meaning of internal states with respect to the stimuli that elicited them. Prior research has connected these functions to a number of prefrontal and cingulate systems.

One structure that is believed to play a critical role in the first component process listed above—generating strategies and maintaining them in working memory—is lateral prefrontal cortex. Both neuropsychological and functional imaging studies have implicated this region as playing a critical role in executive functions that support working memory, reasoning, problem solving, and the ability to generate and organize plans of action (Barcelo & Knight, 2002; Cabeza & Nyberg, 2000; Miller & Cohen, 2001; Nielsen-Bohlman & Knight, 2000; Smith & Jonides, 1999).

The second region that is likely to play a role in reappraising emotional stimuli to alter one's feelings is the anterior cingulate cortex. A number of studies suggest that the dorsal portion of this region (dACC) may be essential for mediating interference between top-down regulation and bottom-up appraisals that generate competing emotional response tendencies (Botvinick et al., 2001; Ochsner & Feldman Barrett, 2001). In this vein, dACC activity has consistently been found in a variety of conditions that involve response conflict (Barch et al., 2001; Botvinick et al., 1999; for reviews, *see* Botvinick et al., 2001; Bush, Luu, & Posner, 2000), including tasks that require overriding prepotent response tendencies (Carter et al., 2000; Peterson et al., 1999). It has been suggested that dorsal ACC works together with PFC during cognitive control: whereas PFC implements control processes, ACC monitors the degree of response conflict or error and signals the need for control to continue (Botvinick et al., 2001; Gehring & Knight, 2000; MacDonald et al., 2000; Miller & Cohen, 2000).

Finally, dorsal regions of medial prefrontal cortex may also play an important role in reappraisal. Activations in this region have been observed when people are instructed to evaluate their own (Lane et al., 1997; Paradiso et al., 1999) or another person's (Gallagher et al., 2000; Happe et al., 1996) emotional state, and when judging the self-relevance of stimuli (Craik et al., 1999; Kelley et al., 2002). Thus to the extent that individuals think about the self when experiencing negative or positive emotions, as may often be the case given the relevance such emotions have for the individual, it is likely that this region may become increasingly active during reappraisal.

## Work Linking the Social, Cognitive, and Neural Levels of Analysis

In the previous sections we outlined findings from social cognitive and cognitive neuroscience research that are relevant for building an integrative understanding of the mechanisms underlying people's ability to cognitively reappraise negative feelings. These findings suggest that the multiple networks of brain regions involved in the generation of emotion, detection of conflict, self-referential processing, and cognitive control are likely to be involved when an individual actively tries to reinterpret the meaning of an emotional stimulus to change the way they feel. In this section, we describe a program of research that has been directly exploring the role that these neural systems play in reappraising negative emotions.

### Neural dynamics of cognitive reappraisal

In one of the first studies on the neural basis of cognitive reappraisal, fMRI was used to examine the regions of neural activity that underlie peoples' ability to cognitively reappraise images that arouse strong negative emotion (Ochsner et al., 2002). Two questions motivated this research. First, what processes are recruited when people reappraise a negative stimulus to reduce its aversive impact? Second, how do brain regions involved in reappraising emotional stimuli impact brain regions involved in generating emotional responses? Drawing from the cognitive neuroscience literature reviewed above, Ochsner and colleagues predicted that reappraisal would lead to increased levels of activity in prefrontal and cingulate regions implicated in cognitive control, and reduced levels of  activity in regions of the brain involved in emotional processing such as the amygdala, insula, and orbitofrontal cortex.

To test these predictions, participants were scanned as they viewed a series of negative and neutral photos drawn from Peter Lang's International Affective Picture System (Lang, Bradley, & Cuthbart, 2005) for eight seconds each. Participants were instructed to simply view each image for the first four seconds. At the four-second mark, participants were cued to either reappraise the image in such a way that they would no longer feel a negative response, or on baseline trials, they were cued to attend to their feelings and let themselves respond naturally. Two contrasts were then performed to test the study hypotheses. A cognitive control contrast compared brain activity on trials when participants were instructed to reappraise the stimuli vs. trials in which they were instructed to simply attend to the stimulus (reappraise > attend). A second emotional processing contrast compared neural activity on trials in which participants simply attended to the photos to trials in which they reappraised the images (attend > reappraise).

Consistent with predictions, the cognitive control contrast revealed significantly more activity in left prefrontal regions implicated in cognitive control processes such as working memory and response selection. Moreover, subsequent analyses demonstrated that the more effective participants were at reappraising to reduce their negative feelings, the more a region of their right anterior cingulate cortex became activated. Given the cingulate's role in monitoring and evaluating the success of cognitive control, this finding suggested that individuals who more closely monitored the selection and application of reappraisal strategies were able to more successfully regulate their negative emotions. Also consistent with predictions, the emotional processing contrast showed increased levels of activity in the left medial orbitofrontal cortex, insula, and the amygdala—a network of brain structures identified in prior research as playing a key role in the processing of affective stimuli.

Taken together, findings from this first study provided preliminary evidence supporting the idea that cingulate and prefrontal systems play a key role in enabling individuals to cognitively reappraise emotional stimuli and regulate negative emotional responses. According to research from the social–cognitive level of analysis reviewed above, however, simply activating these brain systems should not necessarily lead to reductions in brain regions involved in generating emotional responses. Instead, whether reappraisal related activations lead to increases or decreases in such regions should depend critically on what the goal of the reappraisal strategy is–to increase *or* decease negative affect.

To examine whether engaging in reappraisal to achieve different types of regulatory goals influences brain activity, Ochsner and colleagues (2004) conducted a second fMRI study to examine the neural systems that become engaged when reappraisal is used to cognitively turn up (i.e., increase) or turn down (i.e., decrease) negative emotions (Ochsner et al., 2004). In this experiment, participants' use of reappraisal to either increase or decrease the negative affect they experienced as they were shown aversive IAPS images were directly compared. Participants completed three types of trials with aversive photos: baseline *Look* trials similar to those described previously, and *Increase* and *Decrease* trials in which participants appraised the context, affects, and outcomes depicted in photos in either increasingly negative or neutralizing ways. Contrast analyses examining activation on increase trials vs. look trials and decrease trials vs. look trials were then used to examine how engaging in these different types of reappraisal strategies differentially influenced brain activity.

The results from these contrasts indicated that regardless of whether individuals reappraised pictures to increase or decrease how they felt, increased levels of activity were observed in left lateral PFC, dACC, and dorsal MPFC. In addition, both the increase and decrease strategies modulated activity in the left amygdala, with amygdala activity becoming enhanced on increase trials and diminished on decrease trials. Thus consistent with predictions, a common set of structures became active when participants reappraised negative stimuli regardless of whether they did so to increase or decrease how upset they felt.

 In spite of the similarities shared between these two strategies, however, direct comparisons of activity on increase and decrease trials (increase vs. decrease contrasts) revealed some notable differences between them as well. Specifically, increase trials differentially recruited a region of left dorsal MPFC associated with accessing the affective connotations of words and reasoning about one's own or other people's affective mental states (Cato et al., 2004; Ochsner et al., 2004). Decrease trials, on the other hand, differentially recruited right dorsolateral and orbitofrontal regions associated with response inhibition (Konishi et al., 1999) and with updating the motivational value of stimuli (O'Doherty et al., 2003).

The findings reviewed thus far provided evidence that is consistent with the general hypothesis that directing individuals to change the way they feel by directing them to think differently about a stimulus is mediated by prefrontal and cingulate control-systems-involved cognitive control processes. However, as the results just described make clear, different locations within these control systems were identified in the two studies described above, as well as between the up and down-regulate strategy. Ochsner and colleagues reasoned that one reason for this inconsistency could be variability in the specific kinds of reappraisal participants have been asked to employ. There are multiple ways that a person can reinterpret an evocative image to change the way they feel. To the extent that different types of reappraisal strategies involve different types of processing or different types of information, than they might recruit related but distinct neural systems.

To investigate this possibility, participants in the Increase vs. Decrease experiment described above were divided into two groups that achieved their emotion regulatory goals using one of two qualitatively distinct reappraisal strategies. Participants assigned to the *self-focus* group were asked to modulate their negative feelings by either increasing their sense of personal connection to the image (e.g., by imagining it could be a loved one or themselves depicted in the photo) or decreasing their sense personal connection to the image (i.e., by adopting a distant, detached, and clinical third-person perspective while viewing it). Participants assigned to the *situation-focus* group were asked to modulate their negative feelings by either reinterpreting the context, affects, and outcomes of pictured persons in increasingly or decreasingly negative ways. Ochsner and colleagues predicted that the self-focused strategy would differentially recruit MPFC systems involved in self-referential processing and monitoring (e.g. Kelley et al., 2002; Ochsner et al., 2004) because of the emphasis that this strategy placed on thinking about the self. In contrast, they predicted that the situation-focused strategy would more heavily recruit regions of lateral PFC involved in maintaining and manipulating perceptual information (Smith & Jonides, 1998) and retrieving information about emotion-eliciting contexts from semantic memory (Wagner et al., 2001) because of this strategy's emphasis on reinterpreting context.

The results from this study provided mixed support for these predictions. On one hand, results when participants were instructed to down-regulate negative feelings were generally consistent with these hypotheses. On down-regulate trials, participants in the self-focus group displayed significantly more activity MPFC, whereas participants in the situation-focus group displayed significantly more lateral PFC. However, no differences were observed between the situation-focused and self-focused groups when they were instructed to increase their negative emotions. This lack of a difference may have been a result of how participants in the self-focus group were told to increase their feelings. Specifically, they were told to reinterpret the outcomes and affects that they themselves or another person could experience, which is very similar to what participants in the situation- focus group were instructed to do. Future research is thus clearly needed to further unpack the specific mechanisms that underlie the regulatory effects of these difference strategies.

## From Experimental Findings to Individual Differences

The findings from the experiments described thus far highlight a number of specific brain systems involved in reappraising negative
 experiences to make oneself feel better or worse. ↳ Recently, a number of studies have begun to examine whether activity in these regions underlie individual differences associated with populations of people who experience difficulty regulating their emotions.

In one study designed to address this issue, Ray and colleagues (2005) examined whether individual differences in rumination were differentially associated with activity in brain regions involved in generating and regulating emotional responses via reappraisal. Rumination is a process that involves focusing repeatedly and passively on what one is feeling and why one is feeling a certain way (Nolen-Hoeksema, 1991). It has been shown to enhance anger and depression (e.g., Ayduk & Kross, 2008; Bushman, 2002; Kross, Ayduk, & Mischel, 2005; Kross & Ayduk, 2008, 2009; Rusting & Nolen-Hoeksema, 1998), lead to higher levels of depressive symptoms over time (e.g., Nolen-Hoeksema, & Morrow, 1991; Nolen-Hoeksema, Morrow, & Fredrickson, 1993), impair problem-solving ability (Lyubomirsky & Nolen-Hoeksema, 1995; Lyubomirsky et al., 1999), and both precipitate and maintain depressive disorders (Nolen-Hoeksema, 2000). Ray and colleagues predicted that individuals who ruminate may spontaneously reappraise their negative emotional experiences in ways that exacerbate how upset they feel. Consequently, they reasoned that people who score high on a trait measure of rumination might show significantly higher levels of activity in regions of the brain associated with generating emotional responses (e.g., amygdala) as well as brain regions involved in reappraisal (e.g., lateral prefrontal cortex) reflecting their use of reappraisal to enhance their negative emotions.

To test these predictions, Ray and colleagues examined how individual differences in rumination influenced brain activity when individuals reappraised aversive images to either increase or decrease their negative emotional response. This allowed the experimenters to observe whether ruminators were more or less effective at recruiting systems that support reappraisal, or at modulating the appraisal systems that generate the emotional response. Findings indicated that during reappraisal, rumination correlated positively with activity in the amygdala both when individuals were actively turning up or turning down their negative emotion. Interestingly, the tendency to ruminate did not correlate with the tendency to recruit dorsal lateral prefrontal or cingulate regions thought to implement reappraisal processes. Taken together, these results suggested that ruminators may get more "amygdalar bang" for their "prefrontal buck", or in other words, that they are able to efficiently modulate neural systems involved in generating emotional responses and don't need to recruit extra prefrontal resources to do so (for related results with depressed individuals, *see* Johnstone et al., 2007).

In another individual difference study, Kross and colleagues (2007) used fMRI to explore whether individual differences on another personality dimension, Rejection Sensitivity (RS), covaried with activity in brain regions involved in generating and reappraising emotional responses. RS is the tendency to anxiously expect, readily perceive, and intensely react to rejection (Downey & Feldman, 1996). Kross and colleagues predicted that individual differences between high and low RS individuals might result either from high

RS individual's tendency to appraise emotional stimuli as more negative than low RS individuals or their failure to adaptively regulate their negative emotional responses when they become triggered. To examine the role that these different emotional appraisal and control processes play in distinguishing between these two groups of individuals, they scanned high and low RS participants as they viewed images designed to elicit feelings of rejection or acceptance.

Findings indicated that across all participants, the comparison of responses for rejection as opposed to acceptance images showed activation in regions of the brain involved in processing affective stimuli (posterior cingulate, insula) and cognitive control (dorsal anterior cingulate cortex; medial frontal cortex). Low and high RS individuals' responses to rejection vs. acceptance images were not, however, identical. Low RS individuals displayed significantly more activity in left inferior and right dorsal frontal regions, and
p. 86 activity in these areas correlated negatively with participants' ↳ self-report distress ratings. This suggested that the prefrontal regions may play a role in regulating responses to stimuli that convey themes of social rejection. In this vein, it is noteworthy that the activations observed in this study, when participants were free to appraise the meaning of stimuli in whatever way they chose, were very similar to those observed in studies described earlier, when participants were instructed to down-regulate negative responses to aversive images by reappraising their meaning in "cool"' unemotional ways (Ochsner et al., 2002, 2004).

Taken together, these findings help to establish the generalizability of the findings on the neural bases of reappraisal. They demonstrate that brain regions involved in tracking reappraisal when people are instructed to engage in this process also become active during conditions that are diagnostic of theoretically relevant individual differences in which reappraisal processes are believed to play a prominent role.

## From pictures to memories: Towards greater ecological validity

Although the studies reviewed above provide important insights into the neural bases of reappraisal, their reliance on standardized experimental stimuli (e.g., IAPS pictures) to generate emotional responses raises questions concerning the generalizability of the activations observed to "real world" situations. For example, it would be important to know whether the same network of brain regions that underlie people's ability to reappraise aversive images similarly underlie people's ability to reinterpret intense negative life experiences (e.g., being rejected in a romantic relationship; mourning the loss of a loved one) in ways that improve their feelings. Critical here is the question of to what extent do the processes engaged in these different types of emotion regulation paradigms are similar or different.

As a first step toward addressing this issue, we recently conducted an fMRI experiment using a novel memory-based emotion regulation paradigm. In this study, participants were instructed to recall a number of highly arousing negative emotional experiences from (e.g., rejection experiences, hostile arguments, etc.) that they had disclosed during a prior testing session. During the series of blocks completed in the scanner, participants first recalled each experience. They were then asked to use reappraisal strategies designed to either increase or decrease their negative emotional responses (Kross, Davidson, Weber, & Ochsner, 2009). Each block included a brief perceptual reasoning task in which they saw an arrow pointing left or right and were asked to indicate the direction the arrow was pointing. This task was meant to provide a working baseline condition against which reappraisal-related activations could be compared (*see* Raye et al., 2002).

The basic question motivating this study was whether instructing individuals to reappraise feelings associated with aversive memories results in patterns of neural activity similar to those observed when participants are instructed to reappraise how they feel when viewing aversive emotional images. To address this question, contrasts comparing brain activity on trials when participants were instructed to increase and decrease their negative feelings were compared against the perceptual baseline task and then subjected to a conjunction analysis. This type of analysis identifies overlaps in activation observed across different contrasts and thus provides a means of identifying the regions of neural activity that are common to both the increase and decrease reappraisal strategies used in this study.

Consistent with the fMRI studies of reappraisal reviewed above, this analysis revealed that both the increase and decrease reappraisal strategies were associated with increased levels of activity in regions of lateral prefrontal cortex, providing preliminary evidence supporting the idea that lateral prefrontal cortex may provide a common functional architecture for diverse types of reappraisal strategies. These similarities between the memory- and picture-based paradigms notwithstanding, a number of additional activations were also observed in this study. For example, contrasts comparing increase vs. decrease activity revealed significant activations in subgenual anterior cingulate cortex and ventromedial prefrontal cortex, whereas the reverse contrast revealed elevated levels in more dorsal p. 87 ↳ regions of the medial prefrontal cortex. Thus, as one might expect, both differences and similarities characterize what people do in these different tasks. As we discuss in more detail below, one of the critical challenges for future research is to begin to specify what these different activations reflect.

## ASSESSING PROGRESS AND LOOKING TOWARD THE FUTURE

In the previous section, we outlined the basic information needed to adopt a SCAN approach to examine the processes underlying the reappraisal of negative emotional stimuli, and described a program of research that is beginning to use this approach to build an integrative understanding of this phenomenon. In this penultimate section of the chapter, we simulate the final step involved in adopting a SCAN approach, which entails rigorously assessing how well one's studies are meeting their research goals and overcoming the challenges involved in implementing a SCAN approach.

### What Have We Learned and What Do We Still Need to Know?

Perhaps the most robust finding to emerge from the research studies reviewed above concerns the role of lateral prefrontal cortex and dorsal anterior cingulate cortex in modulating emotional responses—either up or down—when people engage in reappraisal. These structures were consistently activated across the research studies described above, regardless of reappraisal strategy, reappraisal goals, or sample population. What's more, activity in these control regions often co-varies inversely with activity in brain regions involved in emotional appraisal. Over the past five years, converging evidence supporting these findings has come from a growing number of studies that also has begun to investigate related forms of cognitive reappraisal. In general, these studies have found that interactions between top-down prefrontal and cingulate systems and bottom-up emotion generation systems are involved when individuals maintain responses to aversive stimuli after they disappear (Schaefer et al., 2002), are instructed to 'suppress' sexual arousal (Beauregard, Levesque, & Bourgouin, 2001), sadness (Levesque et al., 2003; Levesque et al., 2004), or negative motion (Phan et al., 2005), or are instructed to distance themselves from painful inputs (Kalisch et al., 2005). Thus, taken together, the results of these studies suggest that these brain regions are critical to people's ability to cognitively reappraise negative emotional responses (Ochsner & Gross, 2007).

What remains unclear at the moment, however, is what specific psychological processes are reflected by activations in these different brain regions. For example, to what extent does activity in lateral prefrontal cortex activations reflect verbalization, working memory, response inhibition or some other process? Or, how does dorsal cingulate activity interact with lateral prefrontal activity to support reappraisal? Addressing questions such as these is critical to refining our understanding of the processes involved in this type of self-control process and building an integrative understanding of the mechanisms that underlie it. One research strategy that may be particularly helpful towards this end is the use of functional localizer tasks in future fMRI research on reappraisal. Functional localization is a research strategy in which brain regions that are involved in specific types of psychological processes (e.g., self-referential processing, conflict monitoring, cognitive control) are first identified functionally in subjects individually. Subsequent scans in the same subjects then examine whether activity in these functionally defined regions become active when participants engage in a process of interest (e.g., reappraisal). The use of such functional localizer tasks has a long and successful history of use in visual neurophysiology research (e.g., Epstein & Kanwisher, 1998; Saxe, Brett, & Kanwisher, 2005) and offers a route to systematically examining the role that different subprocesses play in reappraisal.

A second issue that remains unclear at present is whether the findings observed thus far on the neural basis of cognitive reappraisal apply to situations in which people are required to regulate their emotions in everyday life. p. 88 ↳ There is little question that repeatedly showing people aversive IAPS images and asking them to reinterpret how they feel in response to viewing them is not the way negative affect is typically triggered and regulated under typical life circumstances. Thus, a critical next step for building an integrative understanding of the processes underlying reappraisal is to examine how the basic findings revealed from the aforementioned studies extend to the range of situations and circumstances in which people are likely to use this strategy in everyday life. In this vein, it is encouraging that researchers are beginning to examine whether the brain systems involved in instructed reappraisal become active when participants may spontaneously engage in reappraisal processes on their own, in the absence of explicit experimental instructions to do so (Kross et al., 2006; Ray et al., 2005). Also encouraging are studies showing similarities between the region important for regulating responses to normatively negative imagistic stimuli and highly self-relevant autobiographical experiences (Kross, et al., 2009). Future research that continues along these lines and builds further is important for establishing the breadth of the findings reviewed in this chapter.

## CONCLUSION

Charles Dickens famously opened his classic novel, *A Tale of Two Cities*, writing, "It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness…." In many respects, we feel that this quote accurately describes the opportunities that currently face integration-minded researchers who are motivated to build cumulative, multi-leveled models of self-control processes. Current opportunities for conducting such integrative research are numerous, as reflected by the amount of funding that has been given to this area, as well as the amount of research that has been conducted recently (Cacioppo, 2007). Thus, times appear to be good in many regards, as measured by a number of different metrics. Times are bad, however, and run the risk of potentially becoming worse, to the extent that researchers who adopt this approach are not mindful of the trade-offs that one is forced to make when moving up and down to different levels of analysis in order to integrate, and do not take efforts to reduce the negative impact of these trade-offs. In this vein, we hoped to convey in this chapter the different kinds of trade-offs that an integrative researcher regularly faces when trying to construct experimental tasks to address the phenomena they care about and the steps that are needed to prevent "foolishness," and instead initiate the construction of an integrative science of self-control. Doing so requires multiple elements: a reasonable understanding of the processes underlying self-control as they have been studied in social-cognition and cognitive-neuroscience, an awareness of the trade-offs that one faces as they attempt to shift up or down different levels of analysis, and the recognition, above all else, that building a cumulative, integrative science of self-control requires the same basic elements as the construction of knowledge in any other research field–well-designed, theory-driven, programmatic studies that systematically examine and test predictions about phenomena of interest. Fortunately, at the moment there exist many examples of integrative researchers who subscribe to this approach. Thus the future seems bright and the best of times, we hope, are near.

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## Notes

* Preparation of this chapter was supported by a grant from the National Institute of Mental Health (MH076137) and National Institute on Drug Abuse (DA022541).